VERTEBRATE PEST TRAINING MANUAL

STATE OF MONTANA
DEPARTMENT OF AGRICULTURE
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PREFACE

In the last several years a feeling of concern for man's environment has become instilled in the minds of the American public. This concern has led to the awareness that broad-spectrum and persistent pesticides, their widespread use, and the eradication of even a single pest species can and do pose serious threats to the stability of our environment and/or ecosystem. Consequently, any pest control program must be carefully considered prior to implementation.

In particular the control of vertebrate pest species (birds, rodents, carnivores, etc.) is complicated by the fact that most are readily visible to the public. The vertebrate pest control issue is further complicated by the fact that many species are extremely beautiful, may be very beneficial at times, and are essential to the ecosystem. At the same time, these species may cause considerable economic damage requiring some measure of control. For these reasons a person initiating a vertebrate pest control program must accept as his primary objective the control of the animals causing the damage - not the entire species causing the damage. By directing control efforts at the segment of the pest population causing the damage, controversy and criticism of the control program can be minimized.

Prior to initiation of a control program it is essential that the biology of the pest species, various management techniques available for controlling the damage, and environmental concerns associated with the control program be considered.

The purpose of the "Vertebrate Pest Management Manual" is to provide interested persons with a basic knowledge of the various vertebrate species which may become pest problems in Montana as well as the management techniques available to alleviate damage associated with each species.

To simplify information, trade named products and equipment have been mentioned. No endorsement is intended, nor is criticism implied of similar products or equipment which are not mentioned.

We wish to acknowledge the help of the following: the Montana Cooperative Extension Service, and personnel of the Environmental Management Division, Montana Department of Agriculture.

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Chapter I

PLANNING A VERTEBRATE PEST MANAGEMENT PROGRAM

The following are five basic steps for planning, implementing, and maintaining a vertebrate pest management program:

A. CORRECTLY IDENTIFY THE SPECIES INVOLVED

Many control operations are started using the wrong techniques and material simply because the individual has not correctly identified the vertebrate pest. This usually results in poor control and increased management problems. There are many sources available to assist the individual in determining the identity of the pest animal. Three useful books are "Field Guide to the Western Mammals", "Mammals of Montana" and "Birds of North America". Copies of these books are available in most libraries. County Extension Agents and employees of the Montana Department of Agriculture's Vertebrate Pest Program, and the Montana Department of Fish, Wildlife and Parks are also available to help identify animals.

B. PROPERLY DEFINE THE PROBLEM AND DETERMINE IF CONTROL IS NECESSARY

It is important to know the type and degree of depredation or damage occurring. For example: Is the damage limited to rangeland? Is soil erosion being accelerated? Is there a potential for disease transmission from the pest animal? Are field crops or ornamentals involved? Is there damage to harvesting machinery? Quantitative answers to these and other questions will assist the applicator, landowner, or manager in determining whether control is necessary, the control strategy, and the approximate amount of time and money to be expended. Each individual landowner or manager must determine if the population of the pest or its damage is significant relative to potential of actual economic damage. He must weigh the benefits (economic, social, environmental, and public health) of control against the actual costs. Control measures should not be undertaken if the costs exceed the benefits.

C. EXAMINE THE HUMAN RELATIONSHIPS INVOLVED

The pesticide applicator should make himself aware of public sentiment in the area toward the pest animal and its control. This consideration is important because the ultimate success or failure of any control program will be determined by the people, especially if public funds are to be expended. Do the producers affected feel neutral about the damage? If so, perhaps control should be reconsidered. Are there persons who object to the idea of killing the target pest? If so, the applicator must be able to explain why the control is needed. If he has properly defined the problem he will be prepared to explain the need for control.

D. ESTABLISH PRIORITIES WITH PRECISE OBJECTIVES

The applicator and others must establish priorities and objectives for each control measure in order to determine the success of the overall program. The best measure of success is not how many target animals were killed, but how much damage was alleviated or potential damage was avoided.

E. TAKE FULL ADVANTAGE OF EXISTING KNOWLEDGE

Some control operations are unsuccessful simply because the applicators are not familiar with the best methods and materials available. It is important to have the latest information on baits, machinery, and other control tools and methods before you begin operations. There are a variety of informative publications available from the Montana Department of Agriculture.

Chapter II

FIELD RODENT PESTS

A. Biology of Field Rodents

Richardson Ground Squirrel (Spermophilus richardsoni)
(Map and Life History - page 7-8)

The Richardson ground squirrel is a fairly small squirrel of the plains regions of Montana. They are the animal many Montanans erroneously refer to as "gophers". The Richardson, like most ground squirrels, is basically a vegetarian. They also commonly feed upon grasshoppers and other similar insects, recently killed members of their own species, and other freshly-killed carrion. In agricultural areas, destruction and consumption of planted seed, small grains and forage crops may be experienced.

Columbian Ground Squirrel (Spermophilus columbianus)
(Map and Life History - page 7-8)

The Columbian ground squirrel is the largest ground squirrel in Montana and is only found west of the Continental Divide and on the east slope of the Rockies. They prefer meadows, open forest, and forest edge habitats.

A small amount of grasshoppers, caterpillars, and insects are eaten, but plant food comprises the majority of their diet. Most observers report that green feed is preferred early in their active season. Columbian ground squirrels compete with cattle and sheep for range forage, interfere with haying operations, and eat cultivated crops. Conscientious application of proper control techniques is required to achieve satisfactory management of this ground squirrel. They are increasing in number in many areas of western Montana in spite of the efforts of producers to control them.

Thirteen-Line Ground Squirrel (Spermophilus tridecemlineatus)
(Map and Life History - page 7-8)

The Thirteen-Line ground squirrel is one of the smallest ground squirrels. They are found over most of Montana east of the Continental Divide except in the south-central portion of the state. They favor brushy edge and tall grass type habitat.

Unlike other squirrels, the Thirteen-Line Ground Squirrel eats a significant amount of insects. Because of this and the fact that they are solitary in their habits, they rarely need to be managed.

Uinta or Armatus Ground Squirrel (Spermophilus armatus)
(Map and Life History - page 7-8)

The Uinta ground squirrel is a medium-size squirrel with a very limited range in Montana. It is found only in parts of Madison, Gallatin, Beaverhead, Stillwater, Carbon, Park, and Sweet Grass counties. This ground squirrel prefers meadow, field edges, and other sites near green vegetation. Although they prefer green vegetation, they will eat seeds, dry herbage and a small amount of insects.

The Uinta, like the Richardson and Columbian ground squirrel, is colonial in nature and can be troublesome when population levels are high.

Northern Pocket-Gopher (Thomomys talpoides)
(Map and Life History - page 7-8)

The Northern Pocket Gopher is distributed throughout the state. This medium sized rodent spends most of its time in its burrow system and is rarely seen above ground. Because of its similar burrowing behavior, it is often mistakenly called a mole. Since there are no moles in Montana, when someone refers to a mole, it can normally be assumed that the "mole" is a pocket gopher.

Pocket gophers feed primarily on underground roots and bulbs and can cause damage to trees, shrubs, lawns, range meadows, and alfalfa crops. The mounds they build cover vegetation and may interfere with hay and grain harvesting equipment.

The Northern Pocket Gopher does not hibernate and hence they will store significant amounts of food underground. They tend to be most active when the soil moisture content is high, but activity periods may vary throughout the year.

Meadow Mice - (Microtus spp.)
(Map and Life History - page 7-8)

Meadow mice are small, prolific rodents. They are common in all areas of Montana where thick grass cover is available. Their presence is usually detected by numerous one to two inch wide runways in the grass and the presence of small, round burrow openings.

Meadow mice can severely damage trees by girdling the trunks and roots. Damage is common in hay and grain crops, particularly to hay bales left in the field for a period of time.

Blacktail Prairie Dog (Cynomys ludovicianus)
(Map and Life History - page 7-8)

The Blacktail Prairie Dog is one of the largest of the squirrel-type rodents in Montana. It is found across most of the

state east of the Continental Divide in dry, prairie-type habitat. Prairie dogs are very gregarious in nature and establish communities commonly known as "dog towns".

Prairie dogs feed primarily on prairie grasses, but may consume a few grasshoppers and other insects. In a heavily populated area the presence of dog mounds and the lack of surrounding vegetation is very evident. In these situations, the numerous holes and lack of available forage can create problems for livestock.

Prairie dogs are not true hibernators and may be seen throughout the year, except during cold periods when they may become dormant.

Striped Skunk (Mephitis mephitis)

Striped skunks are found throughout the state and usually live in underground burrows, rock piles, or hollow logs, and may be found under buildings if construction permits entry. Besides the unpleasant odor associated with skunks, they may be carriers of rabies. Rabid skunks can become very agressive and easily transmit rabies to domestic animals or humans. Large skunk populations may be a potential threat to domestic animals and to humans.

Control of skunks includes preventing entrance to buildings, trapping, shooting, and denning. Trapping, while fairly non-specific, can be effective but includes the potential of scent release. Quick acting poisons such as strychnine treated eggs are very effective but their use is restricted to certain government agencies for the control of rabid skunks. Applicators using toxicants for rabid skunk control must attend a training course and pass an examination administered by the Department of Livestock.

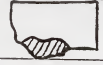
Bats (several species)

Bats are the only true flying mammals. Bats in the northern states feed on large numbers of insects, and, therefore, can be beneficial to man and the environment. They sometimes cause annoyance in homes and buildings because of offensive odors and noises, and their fecal droppings may deface buildings. Rabies in bats sometimes causes community concern, but the part played by bats in the overall ecology of rabies is not understood. Rabies is most frequently transmitted to man from the bite of an infected bat and less commonly from the urine aerosol in caves.

Bats are occasionally a problem when they fly into open windows at night, but they can safely be removed by hands protected with leather gloves. Batproofing with screens or hardware cloth is generally effective and should be done between November and early March when bats have migrated out of the state or are hibernating in caves. If a colony should establish itself in an attic or

some other part of a building, they can be driven out by using chemicals such as naphthalene or paradichlorobenzene. These chemicals should be checked periodically, since they dissipate upon exposure to the air which may allow the bats to reinfest the treated area. Chemicals should not be used as an alternative to batproofing. Rozol tracking powder, registered in Montana under a 24(c) registration (Special Local Need) is available for nuisance bat control and is a restricted use pesticide.

Table 1. Distributions, characteristics, life cycle, food habits, economic importance and control of common field rodents.

SPECIES	GENERAL DISTRIBUTION	WEIGHT	LENGTH		COLORATION	ACTIVE SEASON	BREEDING SEASON
			HEAD & BODY	TAIL			
Richardson Ground Squirrel		3/4-1 1/8 lb.	7 3/4-9 1/2"	2 - 4 1/2"	Smoke-grey to buff	Feb. - March through Sept. - Nov.	March-April
Columbian Ground Squirrel		3/4-1 4/5 lb.	10 - 12"	3 - 5"	Mottled grey with reddish-brown feet and legs	March - April through July - August	April-May
Blacktail Prairie Dog		2 - 3 lb.	11 - 13"	3 - 4"	Yellowish-brown with black-tipped tail	Year round[a]	Jan. - Feb.
Pocket Gopher		1/6-1/3 lb.	5 - 6 1/2"	1 3/4 - 3"	Greyish to black w/much variation	Year round[b]	Feb. to June
Meadow Mouse		1/16-1/8 lb.	3 - 5"	1 - 2 1/2"	Greyish-brown to blackish; much variation	Year-round	Mainly March to September
Thirteen-Lined Ground Squirrel		1/3-1/2 lb.	4 1/2-6 1/2"	2 1/3-5 1/4"	Light to dark brown with 13 whitish stripes on sides & back	April through September	April
Uinta (Armatus) Ground Squirrel		2/3 - 1 lb.	8 3/4 - 9"	2 1/2-3 1/4"	Brownish-black; tail black with some buffy white	March - April through Aug. - Sept.	March

a) Non-specific periods of dormancy
b) Non-hibernator, but digging activity lessens during winter

Table 1. Continued

	LENGTH OF GESTATION PERIOD	LITTER SIZE	HIBERNATION	ESTIVATION	FOOD HABITS	ECONOMIC DAMAGE	POSSIBLE CONTROLS
Richardson Ground Squirrel	30 days	2 - 10	Yes	Yes	Seeds and foliage	Range forage & grain crops	Poison grain bait, toxic gases
Columbian Ground Squirrel	24 days	2 - 7	Yes	Yes	Grasses, seeds, bulbs, berries	Range forage, hayfields, cultivated crops, potential disease reservoir	Poison grain bait, toxic gases
Blacktail Prairie Dog	28 - 32 days	3 - 5	No[a]	a	Foliage and seeds	Range forage	Poison grain bait, toxic gases
Pocket Gopher	28 days	4 - 7	No	No	Mainly roots and bulbs	Hayfields, cultivated crops, rangeland	Trapping, poison grain bait
Meadow Mouse	About 21 days	1 - 9	No	No	Mainly green forage	Hayfields, cultivated crops, orchard trees	Poison bait, habitat manipulation (destruction of cover)
Thirteen-Lined Ground Squirrel	28 days	7 - 10	Yes	No	Seeds and insects	Usually insignificant, because are not colonial	Rarely necessary
Uinta (Armatus) Ground Squirrel	Probably 25-30 days	4 - 6	Yes	Unknown	Mainly green forage	Mainly green forage	Poison grain bait, toxic gases

B. Rodenticides - General Categories

Most toxic materials used for field rodent control can be placed in one of three major categories:

Acute Oral - These are baits impregnated with a toxicant, and death of the animal may result from a single feeding upon the bait.

Chronic Oral - These are baits impregnated with a toxicant which require multiple feedings upon the baits before death occurs. The anticoagulants or "blood-thinning" compounds are found in this category.

Fumigants - These are gaseous toxicants which result in death upon inhalation by the animal.

Changes in pesticide registrations, use patterns, and the development of new and/or modified pesticide formulations can and do affect the types of rodenticides available to the public or to applicators. Hence no attempt will be made to list all of the rodenticides that are currently registered in each category. Some of the more common active ingredients used in rodenticides will be discussed to illustrate the basic effects of each category. A current list of registered rodenticides is available from the Montana Department of Agriculture, Environmental Management Division.

1. Acute Oral Rodenticides

Most of the acute oral rodenticides are mixed with some type of grain as the carrier material for distribution as a bait.

Strychnine, one of the acute oral rodenticides, has been commonly used over the years. It is extremely fast-acting, but its bitter taste can be disadvantageous. For example, if an animal consumes a sublethal dose, it may be able to associate the resulting illness with the bitter taste of the treated bait; and bait shyness may result. Therefore, it is important when using strychnine baits to determine if the target animals are readily eating untreated grain before the toxic grain bait is distributed.

Strychnine is highly toxic to most animal life and should be used prudently to reduce both primary and secondary poisoning hazards to nontarget species.

Strychnine attacks the central nervous system and produces convulsions which ultimately result in respiratory failure. The time between the actual ingestion (swallowing) of the bait and the onset of symptoms is known to vary with the type and amount of stomach contents.

Zinc phosphide is another of the active ingredients used in acute oral rodenticides. When zinc phosphide contacts moisture, particularly acids such as those found in the stomach, it forms phosphine gas which is thought to be the primary lethal agent.

Sodium monofluoracetate (1080) has been used as an acute oral rodenticide. Its apparent lack of odor and taste, coupled with its slow action, are the major reasons for its success. However, the fact that sodium monofluoracetate can remain toxic to other animals even after it has been digested and assimilated into body tissues creates a potential secondary species poisoning hazard. This, coupled with the fact that there is no known dependable antidote, has resulted in a great deal of controversy about the "safeness" of this particular toxicant.

Sodium monofluoracetate (1080) acts to block the citric acid cycle, which is an important life-sustaining chemical process. The main cause of death is generally heart or central nervous system failure.

2. Chronic Oral Rodenticides

There are several anticoagulant baits registered for use on rodents in Montana. The most common active ingredients are diphacinone and chlorophacinone which are formulated as pelleted or grain baits.

Anticoagulants reduce the ability of the blood to clot and death is usually caused by internal hemorrhaging. The major difference between anticoagulants and other toxicants is that anticoagulants generally require several feedings over a period of days for death to occur. The major disadvantage is that a greater amount of the bait must be exposed for a longer period of time. This increases control costs and increases the chances that the bait may be encountered by children, pets, domestic animals, and wildlife.

3. Fumigants

The major fumigant used on rodents in Montana is the gas cartridge. These are 4" x 2" cardboard cylinders filled with mixtures of carbon, lead oxide, mineral oil, phosphorus, potassium nitrate, sodium chlorate, sodium fluoride, sodium fluorosilicate, sodium nitrate, and sulfur. Each tube has a fuse which is ignited before the cartridge is placed as far into the burrow opening as possible. When a dense white smoke appears at the burrow opening, it is immediately covered with a clod of soil and tamped tightly so that smoke and gases remain trapped in the borrow system. If smoke appears at nearby burrow openings, these should be closed to prevent loss of gases and possible escape of the

target species. Gas cartridges are most effective when used in moist soil situations. If the soil is sandy or dry, the gases will escape from the burrow system and their effectiveness will be greatly diminished.

Recently, aluminum phosphide which is primarily used as a stored grain fumigant for insect control, has been registered as a burrow fumigant. Products are formulated in either tablet or pellet form. In the presence of moisture these products release hydrogen phosphide (phosphine) gas. Rate of gas release varies depending on amount of soil moisture present and soil temperature. Under average conditions gas release is slow occuring for as long as 24 hours.

Place 2-4 tablets or 10-20 pellets in each active burrow. Use fewer tablets in smaller burrows under moist conditions and more tablets in larger burrows and dry conditions. Cover the burrow opening with soil after packing the opening with crumpled newspaper to prevent soil from covering the aluminum phosphide fumigant. A length of plastic pipe (1 1/2 - 1 3/4 in. dia.) can be used to place the tablets deep in the burrow systems.

Phosphine gas is highly toxic to humans. Use only outdoors and avoid fumes during use. Hold flask at arm's length and downwind. Phosphine readily absorbs through the skin, especially when the skin is damp. Cotton gloves should be worn during application and disposed of after use. Do not apply under occupied buildings or in burrows that may open under a building. Store in dry, ventilated areas. Do not expose to water or other liquid because this causes immediate release of gas. Do not apply during a rain.

C. Alternative Control Methods

Alternative control methods such as trapping, snaring, shooting and repellents can be effective when rodent populations are restricted to relatively small areas. On large acreages, however, the time required and the cost of the manpower may out weigh the benefits. It may well be that to achieve the control desired, several methods involving both chemical and nonchemical techniques might have to be employed.

The use of biological control agents and chemosterilants is a relatively recent development in the rodent control area. Their effectiveness has yet to be completely evaluated; but if even a few prove to be successful, they will prove yet another way in which rodent damage can be reduced.

Chemosterilants are chemicals that inhibit reproduction, and there are several that have been evaluated on rodents with encouraging results. There is a great deal of interest in the future of chemosterilants because in many instances a greater

long-term population reduction may be obtained by sterilizing rather than killing a portion of the population. Unfortunately, there are no chemosterilants currently registered for field rodent control.

Biocontrol, the use of introduced predators, parasites, or diseases may provide significant help in vertebrate pest management in the future. Currently, however, the potential for harm from these method may outweigh their possible benefits.

D. Management Techniques

1. Toxic Baiting

a. Ground Squirrels and Prairie Dogs

(1) Hand application

The applicator must know the life history of the rodent species to achieve effective control. Such knowledge enables him to properly time the application for maximum safety, selectivity, and effectiveness. The following is a brief discussion of some life history factors particularly important to good control with toxic baits.

An understanding of seasonal activity patterns is critical in determining when to use toxic bait because it is of little value to bait when only a small percentage of the pest population is active. Ground squirrels and prairie dogs both undergo seasonal periods of dormancy in Montana. In the winter, it is called hibernation. If it takes place in the summer, it is termed estivation. Baiting should not be done when a major portion of the population is in estivation or hibernation. The applicator should be watchful for a noticeable decline in the active population, particularly late in the season.

Baiting should not be started with the appearance of the first ground squirrel or prairie dog in the spring, because an important segment of the population may be missed. In many species, the male emerges from hibernation first. Baiting too early primarily kills males, leaving the bulk of the female population uncontrolled. The remaining males will generally be able to breed all the females. Therefore, as many young may be born as would have been if baiting had not been undertaken; and the young born that year may have a better than average change for survival because

of the lack of competition for food and cover with adult males.

The applicator should shoot or trap a number of ground squirrels or prairie dogs before initiating an early season (spring) baiting operation. If both males and females are collected, he is assured that both sexes are active. (Successful baiting at this time may be achieved if the grain bait is readily accepted.) Methods for checking are discussed later.

After the breeding season, some lessening of activity may be observed because the females are in gestation and nursing their young. This is generally a poor time to bait because the females are not as actively foraging for food. Rather than baiting during the gestation or early nursing periods, the applicator should wait until the young appear above ground and begin gathering their own food.

The fact that ground squirrels or prairie dogs are active does not mean that a baiting program will be successful. Some species tend to eat primarily green feed early in the season. Control operations at such times yield poor results because the applicator did not take the time to determine if the grain would be eaten by the target species. A good way to test bait acceptance is to scatter a small amount of untreated grain of the same type used in the toxic bait near 20 to 25 burrows. If acceptance of this untreated grain is poor, there is little chance for good control, and operations should not be initiated until the ground squirrels or prairie dogs are readily eating the untreated grain.

The procedure just described, checking grain acceptance, should not be confused with "prebaiting". Prebaiting is exposing untreated grain to the target species continuously for several days prior to treatment with the toxic bait. This "conditions" the rodent to eating the grain. The conditioned animals will then more readily consume the toxic bait. This increases the likelihood that they will obtain a lethal dose before they begin feeling ill and stop eating. Prebaiting is useful in areas where poor bait acceptance results in unsatisfactory control. Some populations are characteristically harder to control with poison bait because they are naturally suspicious of anything new or different. Other populations of rodents may be "bait shy"

because of improper control procedures used in the past.

When hand baiting with toxic grain, the bait placement is important. Ground squirrel or prairie dog bait should be scattered over an area of a few square feet adjacent to each active hole. The bait should not be placed in piles because this may create a hazard to nontarget wildlife and livestock. Further more, the target species will usually be suspicious of such piles since they are used to foraging for their food. Placing bait in the hole is a poor practice because ground squirrels and prairie dogs usually gather their food on the surface. The bait is more likely to be trampled and buried than eaten.

When choosing the precise spot to scatter bait, remember that rodents are constantly pushing dirt up out of their burrows. Therefore, do not put the bait right in front of the hole where it might be covered by the next load of dirt. A good spot is usually to the side of the burrow where the earth mound and vegetation meet. If the vegetation or terrain are such that the bait would be inaccessible, the applicator may be forced to put it nearer the hole. Another good place to scatter the bait is where obvious signs indicate that the rodents are currently foraging for food.

When hand baiting for ground squirrels or prairie dogs, it is important to place bait by each and every active burrow opening. If burrows or colonies are missed, the animals living in them will be reservoirs for reinfestation of the areas controlled. A good way to insure coverage of an area is for the crew to walk or ride horseback in a line across the area being treated. If several people are involved, the crew chief should make sure that there are no strips of ground that are not covered. An alternate method of achieving good coverage is to divide the treatment area into small sections and assign sections to an individual. The best method to use will be determined by the terrain, the density of the infestation, and the number of people on the crew.

It is common practice in many areas to follow an unsuccessful baiting operation with another a few days or weeks later. This is a very poor and self-defeating practice. Rodents cannot "think" or "reason" in the same sense that man can, but they can learn. One may assume that most of the squirrels or prairie dogs that survive a baiting

operation probably consumed some of the bait. They did not eat enough to kill them, either because they could not find enough, they were not actively eating grain at that season, or they stopped when they started feeling ill. Most of the animals that ate some of the bait probably became somewhat ill from it. Therefore, they have learned to some degree that grain found lying near their burrows is bad for them. In the case of a strong-tasting poison such as strychnine, they may even learn to associate the taste with their illness. The result is that they are even less likely to consume the bait if it is exposed again the same year. This phenomenon is called "bait shyness". Baiting a second time will not only yield poor results, it will reinforce their bait shyness and make control more difficult the following year.

(2) Broadcast Application

Bait for ground squirrels has been applied by aircraft or vehicle-mounted seed spreaders in some areas of the Western states. For aerial applicators, this requires specially modified aircraft and pilots experienced in agricultural work. Check label instructions closely before using these techniques because they may not be allowed. Contact the Montana Department of Agriculture if broadcast application is being considered for information on calbration and rates, application methods and environmental concerns.

The Black-Footed Ferret (Mustela nigripes) which is listed as an endangered species under the Endangered Species Act of 1973 inhabits prairie dog towns where it preys on prairie dogs and lives in their burrows. The use of zinc phosphide or strychnine bait for the management of prairie dogs in towns where the black-footed ferret is known to exist is prohibited. Before using this bait, a black-footed ferret survey is required to determine if any of these animals are present. The United States Fish and Wildlife Service, the Montana Department of Fish and Game, and the Montana Department of Agriculture will provide information on how and/or who is authorized to conduct these surveys.

b. Pocket Gophers

(1) Hand application

Hand baiting is an effective pocket gopher control method when conducted properly. The bait must be placed in the pocket gopher's underground burrows. A pointed steel rod, three eights to one-half inch in diameter, serves as a probe to locate the underground burrow. Probe in the vicinity of pocket gopher mounds until a burrow is located. Make the probe hole about one-half inch in diameter by twisting the probe. Place a small funnel in this hole and drop the proper amount of bait (consult label directions to determine this) in the funnel. Remove the funnel and carefully place a small clod of earth over the probe hole to exclude light. Do not attempt to cover it with loose dirt as it falls through and covers the bait. Bait each burrow system in two or three places. Excessive destruction to the burrow may cause the pocket gopher to become shy of the area.

The probe method of hand application accomplishes two things: it locates the bait in comparatively well-traveled tunnels, and allows bait placement with a minimum of disturbance to the tunnels. If the applicator does not wish to construct and use a probe, an alternative method of bait placement may be tried. This is accomplished by carefully digging out the burrow entrance at the earth mound, placing the bait as far back in the tunnel as possible with a long-handled spoon and then reclosing the burrow with soil.

(2) Mechanical Application

An innovative technique for the control of pocket gophers in large acreages has recently been developed. It involves a machine which constructs an artificial tunnel underground and meters out toxic bait in this tunnel. The machine is called a "pocket gopher burrow builder" and is towed behind a tractor. When used in an area infested with pocket gophers, the artificial tunnels will intersect the natural ones. Pocket gophers then travel down these artificial tunnels and find the bait.

The pocket gopher burrow-building machines are effective tools for pocket gopher control when used properly. However, success with them may be poor if the soil conditions and/or machine adjustment is not correct. Fairly wet soil is required for good burrow formation. If the soil is sandy, it may require even higher moisture for good burrow formation. Therefore, most pocket gopher control is done during the spring and fall

on non-irrigated lands. Where crops are irrigated, the applicator may time the use of the burrow builder to take advantage of moisture provided by irrigation; and he may treat during the summer as well as spring and fall.

c. Meadow Mice

(1) Hand Application

Hand baiting is a practical method of meadow mouse control over small to moderate size acreages. This involves lightly scattering small quantities of bait in mouse runways and near their holes. Complete coverage of the infested area is important because mice are quite prolific and populations can recover rapidly if good control is not achieved.

Anticoagulant baits have also proven effective in meadow mouse control. Because anticoagulants are multiple dose poisons, they are generally exposed in self-feeding bait stations which are maintained as long as there is a threat of damage by the mice.

(2) Broadcast Application

Meadow mice may be controlled over large areas by broadcasting toxic bait by hand or machine. Hand held seeders such as those used to spread fertilizer on lawns provide an excellent means of broadcasting the bait. Baits are usually broadcast at a rate of five to ten pounds per acre, depending upon infestation and the type of bait used.

Tractor and pickup mounted broadcasters and aircraft baiting have also been used effectively in some states to control meadow mice.

2. Trapping

a. Ground Squirrels and Prairie Dogs

Trapping is not a very effective means of controlling ground squirrels or prairie dogs except under special conditions or small infestations. The time and labor involved is generally expensive when compared to the amount of control achieved.

There are, however, trapping methods used for scientific collection or to control small infestations where the use of toxicants is unacceptable. A box-type

live trap is commonly used. Its effectiveness may be increased by tying it open for several days and maintaining food in it. Once the rodents become accustomed to entering it for food, untie the door. When using box traps it is important that they are placed solidly on the ground since most rodents will not enter the trap if it tips or wobbles when they step into it. Small jaw traps may be used to trap ground squirrels and prairie dogs. The California -44- Box Pocket Gopher Trap may be modified by enlarging the trigger slot and used singly or in groups to trap ground squirrels.

b. Pocket Gophers

Trapping is an effective means of pocket gopher control. They travel their burrows a great deal and are very susceptible to properly placed traps. The following trapping method will consistently yield the best results:

Locate a main burrow runway by probing between mounds of earth pushed up by the pocket gopher. (Do not set traps right at the earth mounds because these are usually on short lateral tunnels that are not visited frequently.) A probe can be made by sharpening the end of a three-eights or one-half inch diameter rod to a point. Dig a hole about a foot in diameter down to the burrow. Find where the tunnel enters and exits the excavation. Set two traps, one facing in each direction inwards. The tunnels may need to be enlarged with a hand trowel to allow room for the trap jaws. It is a good idea to attach a light chain or wire to each of the traps and fix it to a painted stake to aid in finding the set. Place a board over the hole and sift dirt around the edges of the board to keep light out. Make one or two such sets in each burrow system. Since pocket gophers are very active in their underground tunnels, properly placed traps will trap them in a matter of hours.

c. Meadow Mice

Meadow mice can be trapped with ordinary wooden-base mouse traps. It is a time-consuming process compared to baiting, and many traps are required. Therefore, it is usually only practical for light infestations or small areas.

Traps set for meadow mice should be placed perpendicularly to their runways. The trigger end should extend out into the runway so that the mouse will run across it. This allows the mice to be trapped

when running in either direction. Traps may be baited with peanut butter, grain, or fresh fruit.

3. Fumigants

a. Ground Squirrels and Prairie Dogs

(1) Gas Cartridges

Gas cartridges that are ignited and placed in the rodent burrow are used for control of prairie dogs and ground squirrels in some areas. Care must be taken when using these devices to seal all burrow openings to prevent the escape of the smoke. Gas cartridges are most effective when high soil moisture conditions permit good sealing of the burrow.

(2) Aluminum Phosphide

Burrow fumigants containing aluminum phosphide are very effective for control of ground squirrels and prairie dogs. For good results care must be taken that soil does not cover the tablets and the burrows are tightly sealed after placement of the pellets in the soil. Because the toxic gas produced (phosphene) is colorless, all burrow must be treated.

b. Pocket Gophers

Toxic gases are generally not effective against pocket gophers because of the extensive nature of the burrow systems and the pocket gopher's habit of plugging the burrow between himself and the gas source when it detects the unusual odor.

c. Meadow Mice

Toxic gases are generally not effective for meadow mouse control because of the nature of their burrow system.

4. Habitat Manipulation and Management Practices

Habitat manipulation is used with varying degrees of success in different regions of the United States. To alleviate a rodent problem in areas where diverse vegetative habitats exist, it may require such extensive manipulation that the end result would be too damaging to nontarget species. Habitat manipulation involves such things as destruction of food, shelter, cover, or other habitat requirements of the pest species. Burning of fence rows and irrigation ditch banks, flood irrigation, and cleanup of old wood piles are

effective in eliminating food, cover, and nesting areas for rodents.

Before starting a habitat manipulation program, determine what other wildlife species are present in the area and what effects the manipulation may have on them. Of all the methods, this one may have the greatest effect on nontarget species and in some cases should be recommended only as a last resort.

a. Ground Squirrels and Prairie Dogs

It is difficult to manipulate the habitat of ground squirrels or prairie dogs in order to reduce their damage without causing detrimental effects to nontarget species utilizing the same area.

b. Pocket Gophers

Flood irrigation is an effective deterrent to high pocket gopher populations. Many ranchers in Montana have reported a dramatic increase in pocket gopher populations when switching from flood to sprinkler irrigation.

c. Meadow Mice

Clean farming management practices can often be used quite effectively in an overall meadow mouse control program since cover is very important to them. If fields and orchards are kept free from tall grasses and weeds, mouse populations will have difficulty in sustaining high, damage-causing levels. It should be noted, however, that these clean farming practices may also adversely affect some desirable species, such as gamebirds, that depend upon the same type of vegetation for food and cover.

Chapter III

PREDATORS

A. Biology of Predators

Coyote (Canis latrans)

The coyote is the most abundant canine predator in Montana. This dog-like mammal (adults may weigh from 20-59 lbs.) is extremely adaptable in both its food habits and habitat preference throughout its range.

The coyote is most active during the night, but may be seen during the day. The staple part of the coyote's diet is small rodents and rabbits, but they will supplement this diet with vegetable matter, insects and larger mammals on occasion. Because of the fact that they will, and do, take domestic livestock (sheep, calves, poultry), they are not held in high esteem by many livestock producers.

The adult coyotes breed in January and February, and the pups (usually 5 to 10) are born in April or May. They normally build their dens (while raising the young) in the ground, but they may choose other shelters in rocky and mountainous terrain.

Over the years there have been numerous control programs instituted against the coyote. Some of these programs have resulted in temporarily decreasing coyote populations, at least in localized situations.

Red Fox (Vulpes fulva)

The red fox is normally 1/2 to 3/4 the size of the coyote (10-20 pounds) exhibiting many color variations such as the cross fox which has a dark area over the shoulders and down the middle of the back and the silver fox which is black with white-tipped body hairs. All color variations are identified as the red fox by the white tip on the tail. They have been seen throughout Montana, but are most abundant in the western one-fourth of the state with scattered populations in the central and eastern portions.

The red fox is most active during the night, early morning, and evening hours. Their food consists of animals ranging in size from insects to rabbits, with mice comprising the major portion of their diet throughout the year. Foxes will occasionally take poultry and small lambs and hence can be a problem to livestock producers in some areas.

The young are normally born in March or April (4 to 9 per litter) and remain with the adults until fall.

B. Management Techniques

Over the years numerous coyotes and fox management programs have been instituted. Some of the programs have only been slightly successful, while others have been moderately successful, at best. Many of the successful programs have been those in which several management procedures (tools) were used. The reason for this is that both coyotes and foxes apparently learn fairly quickly and hence may become bait or trap shy very early in a control program. If a trapping program was being conducted and the animals became trap shy, obviously the success of the program would be low. Therefore, several other management methods should be incorporated into the overall program.

1. Traditional Methods

Denning, trapping, and shooting are the traditional methods of management for coyotes and foxes. If the predator density is high, these methods may prove to be effective in localized situations. The type of terrain and available manpower will obviously affect the degree of success that these programs might have.

2. Predacides

The compound 1080 (sodium monofluoroacetate) was used as a predacide in station baits from the late 1940's until 1972 when its use as a predacide was cancelled. Although 1080 was effective as a predacide, it did present several problems. The major problem was its slow action. It had to be taken into the body and assimilated into the body tissues before it took effect. Once it was in the tissues it blocked the citric acid cycle (which is an important life sustaining chemical process) and death resulted from cardiac or central nervous system failure. Because of this slow action, an animal could move several miles before death ensued. A secondary problem arises in that 1080 may remain toxic to other animals after it has been digested and assimilated into body tissues. So other predators and scavengers might be killed if they fed upon the poisoned animals.

There is a possibility that 1080 will be used as a predacide in the future if some of these problems can be overcome. For example, if a baiting system could be devised in which the exposure of nontarget animals to the toxicant could be significantly reduced or eliminated, there might be a chance that the use of 1080 as a predacide would be reconsidered.

In November of 1975 the Montana Department of Livestock was granted registration of sodium cyanide capsules for use in the M-44 application device. Sodium cyanide is a highly toxic chemical, and it acts very quickly - hence it is an

ideal predacide. When used in the M-44 device, it is fairly selective for the candid species.

An attractant is applied to the outside of the case holder on the device, and this serves to draw the coyote to the device. When the coyote pulls on the case holder, the sodium cyanide is ejected into his mouth. It is rapidly absorbed; and since it is a chemical asphyxiant, it prevents the utilization of oxygen at the cellular level by inhibiting the activity of the tissues oxidative enzymes. Since the function of cellular respiration is necessary for life, any degree of interference with this function quickly causes serious illness or death.

Sodium cyanide is a restricted use pesticide, and the law requires that an individual using it be certified and licensed as a pesticide applicator. In Montana, private landowners, as well as state and federal employees, may be licensed to use the material. Before being licensed, however, the prospective applicators must attend a training session and pass a written examination as required by EPA regulations and the Montana Pesticide Act. The Montana Department of Agriculture conducts the necessary training and administers the examinations. Once licensed it is the responsibility and obligation of the trained applicator to follow the precautionary statements, directions for use, and other pertinent information stated on the label.

Chapter IV

Bird Pests

A. Migratory Bird Treaty Act

Most of the major bird species are not considered to be pests, and in fact, are probably considered by most people to be beneficial. Wild bird species are a source of enjoyment for many people and can be beneficial by eating undesirable insects and weed seeds. Upon occasion, however, certain species can become pests or compete with man's interests. When these situations occur, control measures may be necessary.

Many people are uncertain about which birds can be legally controlled and which cannot. The Migratory Bird Treaty Act, 1918, as amended, states that it is unlawful to pursue, hunt, take, capture, kill, possess, sell, purchase or transport any migratory bird, or any part, nest, or egg of any of the birds included in the terms of the conventions except as permitted by the Secretary of the Interior in the manner prescribed by the Act. The exceptions are provided because it is recognized that at times a reduction in bird numbers is essential to man's economic pursuits.

The Code of Federal Regulations (Part 21 of Title 50--Wildlife) allows a farmer to apply for a permit to control migratory birds that are causing damage to his crops. This permit can be obtained from the U.S. Department of Interior, Bureau of Sport Fisheries and Wildlife. Section 21.43 of this part also allows a person (without a permit) to control yellow-headed, red-winged, bicolor red-winged, tricolor red-winged, and Brewer's blackbirds, cowbirds, and all grackles, crows, and magpies found committing or about to commit depredations upon any agricultural crop or ornamental or shade tree. Since this is a very sensitive area, it is a good idea to contact the Vertebrate Pest Program of the Montana Department of Agriculture for advice and recommendations before instituting control measures.

In Montana the birds that are apt to be pests and that do not require permits for control are the common pigeon, the house sparrow, and the European starling.

B. Biology of Bird Pests

House Sparrow (*Passer domesticus*)

The house sparrow is familiar to almost everyone since it is quite adaptable and is found in virtually all types of rural and urban settings. The males' black throat, white cheeks, and chestnut nape separates it from its country cousins and most of the other similar-sized bird species.

The house sparrow frequently builds bulky nests in and around buildings and may cause fire hazard problems, plugged roof drains, as well as contamination of stored foods.

Common Pigeon (Columbia livia)

The domestic pigeon or rock dove is typically gray with a white rump, broad black band on the tail, and red feet. These birds are commonly found in cities and on farms, and the droppings they leave on buildings and sidewalks are familiar to both farm and city dwellers. They nest on ledges and in open portions of upper levels of buildings. They can cause contamination of on-farm storage of grain if the storage facilities are not properly constructed. Several fungal diseases, including ornithosis, are transmitted by pigeons. The potential for disease transmission increases as humans are exposed to pigeons' droppings and resultant dusts.

European Starling (Sturnus vulgaris)

A very gregarious, short-tailed "blackbird" whose general body shape resembles that of a meadowlark. In the spring of the year the bill becomes yellowish and the feathers become glossed with purple and green.

This bird is a greater problem in rural areas than in cities, particularly in stock feeding operations where they consume and contaminate considerable amounts of food. They may become a problem in cities when they seek the warmth and shelter of buildings during cold weather. Objections have also been raised concerning their habit of usurping the nesting sites of native birds, such as woodpeckers, swallows, and bluebirds.

Blackbirds (several species)

Blackbirds, cowbirds, and grackles are protected under the Federal Migratory Bird Treaty Act, but may be controlled if they are committing or about to commit depredations upon agricultural crops.

Cereal grains are especially attractive to these birds (since they are primarily seed eaters), and they are capable of causing severe damage in localized areas. In Montana they gather in flocks in late summer and early fall and feed on crops such as corn, sunflowers, and small grains.

Magpies and Crows

There are no avicides registered in Montana for the control of depredating magpies and crows. Shooting or trapping are the only legal methods of control available to a landowner.

C. Management Techniques

Pest bird control in and around buildings primarily involves good sanitation (reduction of food sources) and construction of structural features which discourage nesting. Exclusion devices such as hardware cloth or nylon or plastic netting can be used on existing structures. Repelling devices like nontoxic sticky substances or porcupine wire strips may be effective. Trapping may be effective in reducing local birdnumbers in localized situations (such as pigeons). Shooting, primarily pigeons, with air powered pellet rifles can be effective but is highly labor intensive. Frightening techniques like scarecrow devices including dummy hawks, owls and snakes, shiny foil stripes, flashing lights or various acoustical devices have not been found to be effective except perhaps for a few days.

Available avicides are registered only for specific species so the label should be checked closely before using.

1. Toxicants

Avitrol (4 -aminopyridene) is a bird management chemical registered for use as a flock frightening repellent. It is applied to grain, and the resultant treated bait is diluted with untreated bait so that only a few birds in an area ingest treated particles of the bait. Affected birds emit distress cries and perform aerial distress displays and often frighten the other birds in the area and cause them to leave.

Avitrol is the registered trademark of the Avitrol Corporation, and products are for use by or under the supervision of government agencies or pest control operators.

There are several products available that can be applied to roosting areas that are effective on species such as pigeons, house sparrows and starlings. The problem with these products as well as with the Avitrol product is the possibility of taking desirable nontarget birds along with the target species.

Bait materials treated with strychnine have been used in the past with varying degrees of success. Poor selection of baiting sites, poor preparation of the bait material coupled with the nonselective nature of strychnine may resulted in the loss of nontarget birds and mammals. This potential has resulted in an adverse public reaction, and in many areas the use of strychnine is frowned upon by the general public because of the associated hazards and uncertainties.

Toxic bird perches which wick a liquid toxicant to perching bird's feet and inturn is absorbed into the body are effective pest bird control devices. Perch design and

placement make these perches species specific. When toxic perches are used properly there is seldom concern for nontarget birds.

2. Frightening Techniques

The .22 caliber rifle when used with hollow point ammunition can be very effective in frightening blackbirds from open fields. In crops such as sunflowers or corn, shooting is more effective if it is done from an elevated stand. This gives the shooter a better view of the field and allows him to place his shots closer to the depredating birds.

The shotgun with standard shotgun shells is fairly effective along flight lines where birds are entering or leaving a field, but the birds may learn that it is not harmful if they stay out of range. A variation of this is the exploding shotgun shell which is a shell containing a large firecracker rather than pellets. When fired, the firecracker is propelled 100 or more yards into the field before it explodes.

The use of guns as frightening devices requires frequent harassment and obviously requires time and patience on the part of the producers. In the long run, this may be as effective and no more costly than other methods.

There are several types of gas exploders that have been used to reduce destruction by blackbirds and starlings and to deter them from their roosting areas. The various machines available differ in construction but are similar in principle, i.e., most use acetylene gas to produce the explosion. To be used effectively these devices should be moved frequently, and in some cases be used intermittantly to prevent the birds from becoming accustomed to the noise.

3. Trapping

Trapping is generally ineffective in most field situations, but it may be effective for certain species (such as blackbirds, starlings, pigeons, and magpies) around localized areas such as cattle feedlots, hog pens, and corrals.

4. Miscellaneous Devices

Scarecrows and similar devices are generally ineffective. More elaborate creations with moving parts may prove efficacious when used in combination with another method such as shooting.

Shiny objects that flash or twirl in the wind can be effective, particularly in small areas.

White rags tied by two corners to cornstalks flap in the breeze and may give the appearance of people working in the field to birds flying overhead.

Chapter V

COMMENSAL RODENTS

A. Biology of Commensal Rodents

The term "commensal rodents" refers to three rodents introduced into North America from Europe. These rodents are the Norway rat, the roof rat (not present in Montana), and the house mouse. These rodents can cause a great amount of destruction of food and property. They can also be a source of such human diseases as plague, murine typhus, leptospirosis, rat bite fever and trichinosis. Mice are also known to transmit rickettsial pox. Rats in slum areas have been known to kill or maim babies in their beds.

Norway Rat (Rattus norwegicus)

The Norway rat is predominantly a burrowing rodent and is the most common and the largest of the domestic rats. Adults usually weigh about one pound and vary from a reddish to a grayish brown in color, with many variations.

In an outdoor situation, rats are found in burrows in the ground, under foundations of buildings, around barns and grain storage bins, and in garbage dumps. In buildings they are normally found between the floors and walls; in enclosed spaces in cabinets, shelving, appliances; and in piles of rubbish.

The Norway rat is an omnivorous animal (eats both animal and vegetable matter). They will eat all types of animal and vegetable products and by-products, hence the attractiveness of garbage dumps. In rural areas cereal grains may be a major part of their diet. Rats normally require at least an ounce of water every day.

House Mouse (Mus musculus)

The house mouse is the smallest of the domestic rodents and is virtually found everywhere in the United States. Adults are a dusky gray in color and weigh less than one ounce.

The house mouse will use almost any type of building or structure as a harborage. They commonly nest in spaces in walls, floors, cabinets, furniture, and appliances. House mice seem to prefer cereal grains but will eat most food garbage. They require very little water and can obtain enough water in the food they eat.

B. Recognizing Rat and Mouse Signs

Rats and mice are habitually nocturnal and secretive and are rarely seen during the day except when infestations are heavy. Therefore, it is necessary to interpret signs of their activities

properly in order to plan control work. These signs are found in secluded places, such as along walls, under piles of rubbish, and behind or under boxes, boards, and thick vegetation. From the rodent signs, one can tell the species present, and whether a rodent infestation is current or old, heavy or light.

1. Droppings

Fresh droppings of feces are usually moist, soft, shiny, and dark, but in a few days become dry and hard. Old droppings are dull and grayish and crumble when pressed with a stick. Norway rat droppings are 1/2 to 3/4/ inch long and are blunt-ended. House mouse droppings are 3/16 to 1/2 inch long, are not as thick as rat droppings, and have pointed ends.

2. Runways

Rats habitually use the same runways between food, water, and harborage. Because of the keenly developed sense of touch in their vibrissae (whiskers) and in specialized hairs along the body, rats prefer continual body contact with at least one vertical surface, such as a fence or wall. Rats also follow "odor trails". Outdoors, their runways are narrow pathways of beaten earth swept clear of debris. Indoors, greasy runways are found along walls, steps, and rafters. Undisturbed cobwebs and dust in a runway indicate that it is not in use.

3. Rubmarks

Along regularly traveled runways, a dark, greasy mark forms from contact by the rodent's body. Fresh marks are soft and will smear if rubbed. As the grease ages, it dries and gathers dust and will flake off when scratched with a fingernail. The rubmarks of the Norway rat are most commonly found along runways near ground or floor level. Mice do not leave detectable rubmarks except when the infestation is heavy.

4. Burrows

The Norway rat prefers burrows for nesting and harborage. Burrows are found in earth banks, along walls, under rubbish or concrete slabs, and in similar places. If a burrow is in use, its entrance will be free of cobwebs and dust. Fresh rubmarks on hardpacked soil at the opening indicate a well established and presently used burrow. The presence of fresh fragments of food or freshly dug earth at the burrow also indicates current use by rats.

5. Gnawings

The incisor teeth of rats grow 4-5 inches a year, so these rodents must do some gnawing each day in order to keep their teeth short enough to use. Rats also gnaw to gain entrance and to obtain food. When gnawings in wood are fresh, they are light-colored and show distinct teeth marks. Small chips of wood or other materials indicate recent gnawing. With age, wood gnawings become dark and smooth from weathering and from frequent contact with the rodent's body.

6. Tracks

Fresh tracks are sharp and distinct, whereas old tracks are covered with dust and are, therefore, less distinct. The tracks of the 5-toed rear paws are more commonly observed than are the 4-toed front paws, but both may be present. Smooth tracking patches of any dust material, such as flour or talc, placed along runways, are of value in checking for rodent activity. To see tracks in the dust, the applicator should hold a flashlight at an angle that causes the tracks to cast distinct shadows. Tail marks, too, are often visible in dust or tracking patches.

C. Management Techniques

The successful control of a commensal rodent population is only accomplished by preventing their access to food and harborage. Involvement of the community is a must if an effective rodent control program is to be initiated. Such a program involves 3 parts carried out simultaneously:

1. Stoppage - preventing entry by construction.

The best program of rodent control is one which prevents rodents from entering. Although this may be an impossibility, much can be done to minimize entry. Whenever possible stoppage should begin when construction starts.

To prevent entry, footings should extend into the ground at least 2 feet and have an apron that extends 8-12 inches outward. In sandy soils, however, burrows may go down several feet.

Ground floors should be 18 inches above ground or be constructed of concrete. Foundations and footings should be well constructed of poured concrete or stone and mortar, brick and mortar, etc. Placing a termite shield between concrete and wood helps prevent rodents from finding an entry at this point. All too frequently space is left where siding, framing and foundation come together. Good construction can prevent this.

Underpinning, skirting and above ground foundation walls of existing homes and other buildings should be inspected carefully for evidence of cracks and holes. Pay particular attention again to the junction of siding, framing and foundation of skirting. Older buildings may require a curtain wall of concrete.

Also pay attention to covers for crawl space ventilators. Vents should be covered with a metal grillwork, backed by rust resistant screening. Remember a house mouse can get through a space approximately 1/4 inch in diameter.

Points where pipes, conduit, and wiring enter at or below grade should be examined to be certain the space between them and the wall be sealed.

Basement floors should be concrete not wood or earth.

All openings within four feet of final grade or which could be reached by climbing must be rodent-proofed. Windows should be screened. Vent openings should also be screened or have movable metal flaps that open when the ventilating fan is working and close tightly when it is off.

Doors, exterior and interior, should fit tightly and be kept closed except when used. If necessary, install dutchman and metal cuffs on doors to make them rodent-proof.

If the home has a fireplace and chimney with a footing in the crawl space, check very carefully where the chimney comes through the floor. Flash or caulk to insure a tight fit.

Roofs should be checked to see that shingles are down tight and sheathing is complete. Also, look over ventilation in the roof area. Screen vents and louver-in wall vents. Use hardware cloth (1/4 inch mesh) with insect screening to prevent larger animals from entering through vents. Screen shimneys, ventilators, and vent pipes if they are serving as entryways.

2. Elimination of food, water and harborage.

It is not always possible to build rodents out completely, therefore, it is necessary the interior resembles as closely as possible a rodent desert. This means premises should be cleaned up and changes made in interior arrangements insofar as possible so that food, water and shelter are not available. There are a number of things which can be done. Of primary importance is the proper maintenance of sanitary landfills to ensure the unavailability of this food source to commensal rodents.

Use care with food handling so food is not available to rodents. Check bulk food containers, such as boxes and baskets used for produce, for rodents. Put flour and similar foods in rodent-proof containers. Clean up food spills and crumbs immediately.

Remove debris piles inside and outside. Place stacked material 8 to 12 inches above floor and away from vertical surfaces.

crawl spaces beneath buildings and stairways and stairways should be kept free from debris.

Keep shrubbery trimmed, cleaned and free of leaves or other material. Grass areas should be kept closely mown. Do not plant shrubbery and other plants against walls; prune or remove existing plants.

Inside the home, built-in appliances and cabinets should either be set closely against walls to make sure there is no passageway or out sufficiently so a check can be made to see spaces are not being used as travelways. Lower shelves should either be on the floor or raised so that they can be checked beneath easily. Small spaces behind appliances and beneath shelving often provide excellent rodent shelter.

The "secret" is to examine areas in terms of animal requirements and remove these whenever possible.

3. Population reduction - traps and/or toxicants.

It is not always possible or practical to completely stop rodent entry or to prevent all access to food, water and shelter. In such cases it becomes necessary to reduce the rodent populations directly. In addition, when the decision is made to undertake a program of stoppage and limiting access to requirements, the existing rodent populations should be reduced. This will minimize rodent migration to new areas where they would become a problem. The two most common ways are traps and poisons.

a. Trapping

Traps are a preferred method of control where rodenticide use should be avoided, when dead animals may die in an inaccessible area and cause annoying odors, or where a few surviving rodents become poison bait shy. Both wood base and steel traps are effective. Mice are easily trapped with snap traps whereas rats tend to be more wary and consequently are more difficult to trap.

Mouse traps must be set closer together (3-4 foot intervals) against baseboards, boxes and platforms.

Baits for house mice include rolled oats, peanut butter, gum drops, raisin bread, bacon and nut meats. Traps for rat control should be placed in rat runs. Baits for rats include bacon, fish, ground meat, raisin bread, nut meats, prunes and apples.

An alternative to traps is glue boards, which will catch and hold rats and mice when they cross them, similar to the way flypaper catches flies. Place along travel ways, especially along walls. Glue boards loose their effectiveness in dusty environments unless they are covered. They are more effective in catching mice than rats. Do not use glue boards where children, pets or wildlife can contact them.

b. Rodenticides

Toxicants used for rodents are two types: multiple dose (anticoagulants) and single dose (such as zincphosphide). The acceptability of a rodenticide bait is a critical factor in controlling rodent populations. Often a "trial and error" approach in finding a bait acceptable to specific rodent populations is necessary.

Norway Rats

A number of baits are used for Norway rats: grain, seeds, legumes, bacon, fish, sugar, corn, fruits (e.g. apples and tomatoes), vegetables, mineral, peanut and salad oils are frequently used. Wheat, corn, oats, and barley are most commonly used in poison baits. Baiting problems may be related to food availability rather than the rodenticide employed. Improper placement and distribution may be responsible for control failure. In food warehouses cereal baits may not be accepted and liquid baits may be desirable. In extremely moist areas (indoors or outdoors) paraffin treated baits may retard the deterioration of the baits, prolonging its acceptability.

House Mice

Mice do not forage widely, therefore, the use of many well distributed small anticoagulant baits is preferable. Because mice nibble when feeding, a high concentration of anticoagulant is required to reduce control failures. Frequent renewal of baits is a must since mice reject old baits. Liquid baits are usually not desirable because mice have low water requirements. Rodent ectoparasites can be controlled at the same time as rodents. Spreading insecticide dust in runways or in burrows is the recommended procedure.

(1) Multiple-Dose Anticoagulant Rodenticides

Anticoagulant poisons include pivalyn, warfarin, diphacinone, fumarin, and chlorophacinone. They must be eaten by rodents over a period of several days and should be made available for a period of 10 to 20 days. Establishment of permanent bait stations in places subject to continued reinfestation gives good control, provided old baits are periodically replaced by fresh ones. Liquid baits work best where the rodent's water supply can be controlled. For house mice, fresh bait should be made available for a minimum of 14 days.

(2) Single Dose Anticoagulant Rodenticides

These rodenticides include bromadiolone and brodifacoum. Both of these chemicals can cause mortality in rats and mice after a single feeding. Although only a single feeding is required, baits must be available on the treatment site for at least 15 days or until feeding stops to assure all the rats and mice present have an opportunity to feed in the bait. Like the multidose anticoagulants, permanent bait stations may be established to control areas where reinvasion is likely.

(3) Single-Dose (acute poisons) Rodenticides

Single dose rodenticides include sodium fluoroacetate (1080), and zinc phosphide. Pre-baiting (offering untreated bait for several nights prior to adding poison) will greatly increase the effectiveness of acute poisons.

(a) Alpha-chlorohydrin is a toxicant-sterilant for use against Norway rats. Depending on dosage, it will temporarily or permanently sterilize adult male Norway rats or is lethal to both sexes.

(b) Bromethlin is a rodenticide effective against rats and mice that apparently interups the energy cycle within the cells of the central nervous system.

(c) Cholecalciferol is Vitamin D_3 which in high dosages causes hypercalcaemia or movement of calcium from the bone into the blood stream resulting in dealth from heart failure.

(d) Zinc Phosphide is effective against all three domestic rodents. Zinc phosphide is moderately fast acting. This poison releases phosphene gas when it contacts stomach acids. The odor of this chemical may result in bait shyness if there is poor bait acceptability by the target rodents.

(e) Sodium Fluoroacetate (1080) is highly toxic and its use is restricted to special situations, and to professionally trained personnel. There is no known antidote for this poison. Compound 1080 are effective against Norway rats, roof rats, and house mice.

Compound 1080 should be placed in locked bait boxes and all precautions needed to protect children, pets and wildlife from contacting the chemical should be taken.

(4) Tracking Powders

Tracking powders are dust formulations that contain a rodenticide like zinc phosphide or an anticoagulant. The material is injested during grooming after the rodents have tracked through the powder. The dust must be placed where the rats or mice are known to frequent and in areas or containers not accessible to nontarget animals.

Nontoxic tracking powders can be used to monitor rat and mouse activity in an area by observing the tracks made in the dust.

(5) Fumigation

Another method of reducing commensal rodent populations is fumigation. Fumigation provides a quick kill, however, rodents will die in inaccessible areas and decompose and produce odors. For these reasons it is not recommended for general rodent control. Unless a situation absolutely warrants their use, fumigants should not be considered. Fumigants should be applied only by trained personnel.